ZOOLOGIA 37: e46392
ISSN 1984-4689 (online)
zoologia.pensoft.net

RESEARCH ARTICLE

Taxonomic Catalog of the Brazilian Fauna: order Trichoptera (Insecta), diversity and distribution

Allan P.M. Santos[1], Leandro L. Dumas[2], Ana L. Henriques-Oliveira[2], W. Rafael M. Souza[2], Lucas M. Camargos[3], Adolfo R. Calor[4], Ana M.O. Pes[5]

[1]*Laboratório de Sistemática de Insetos, Departamento de Zoologia, Instituto de Biociências, Universidade Federal do Estado do Rio de Janeiro. Avenida Pasteur 458, 22290-250 Rio de Janeiro, RJ, Brazil.*
[2]*Laboratório de Entomologia, Departamento de Zoologia, Instituto de Biologia, Universidade Federal do Rio de Janeiro. Avenida Carlos Chagas Filho 373, 21941-971 Rio de Janeiro, RJ, Brazil.*
[3]*Department of Entomology, University of Minnesota. 1980 Folwell Avenue, 219 Hodson Hall. St. Paul, MN 55108, USA.*
[4]*Laboratório de Entomologia Aquática, Departamento de Zoologia, Instituto de Biologia, Universidade Federal da Bahia. Rua Barão Geremoabo 147, 40170-115 Salvador, BA, Brazil.*
[5]*Coordenação de Biodiversidade, Instituto Nacional de Pesquisas da Amazônia. Avenida André Araújo 2936, 69067-375 Manaus, AM, Brazil.*
Corresponding author: Allan P.M. Santos (allanpms@gmail.com)

http://zoobank.org/1212AFDC-779B-4476-8953-436524AAF3EC

ABSTRACT. Caddisflies are a highly diverse group of aquatic insects, particularly in the Neotropical region where there is a high number of endemic taxa. Based on taxonomic contributions published until August 2019, a total of 796 caddisfly species have been recorded from Brazil. Taxonomic data about Brazilian caddisflies are currently open access at the "Catálogo Taxonômico da Fauna do Brasil" website (CTFB), an on-line database with taxonomic information on the animal species occurring in Brazil. The order Trichoptera at CTFB includes a catalog of species recorded for the country, with synonymic lists, distribution throughout six biomes, 12 hydrographic regions, and 27 political states (including Federal District) from Brazil. The database is constantly updated to include newly published data. In this study, we reviewed the taxonomic effort on Brazilian caddisflies based on data currently in CTFB database. The accumulation curve of species described or recorded from the country, by year, shows a strong upward trend in last 25 years, indicating that it is possible that there are many more species to be described. Based on presence/absence of caddisfly species at three geographic levels (biomes, hydrographic regions, and states), second order Jackknife estimated at least 1,586 species occurring in Brazil (with hydrographic regions as unities), indicating we currently know about 50% of the Brazilian caddisfly fauna. Species distribution by Brazilian biomes reveals that the Atlantic Forest is the most diverse, with 490 species (298 endemic), followed by the Amazon Forest, with 255 species (101 endemic). Even though these numbers may be biased because there has been more intense collecting in these two biomes, the percentage of endemic caddisfly species in the Atlantic Forest is remarkable. Considering the distribution throughout hydrographic regions, clustering analyses (UPGMA) based on incidence data reveals two groups: northwestern basins and southeastern. Although these groups have weak bootstrap support and low similarity in species composition, this division of Brazilian caddisfly fauna could be related to Amazon-Atlantic Forest disjunction, with the South American dry diagonal acting as a potential barrier throughout evolutionary time.

KEY WORDS. Caddisfly, aquatic insect, taxonomy, biodiversity, Neotropics.

INTRODUCTION

The caddisflies, order Trichoptera, represent a diverse lineage of aquatic insects, currently with more than 16,000 named species (Morse et al. 2019). They are sister group to the megadiverse order Lepidoptera, and together they constitute the well-defined superorder Amphiesmenoptera (Kristensen 1997, Misof et al. 2014). Trichoptera are known from all zoogeographic regions, except for the Antarctic Region, and they are particularly diverse in Neotropical and Oriental regions (de Moor and Ivanov

2008). In the most recent Neotropical catalog, Holzenthal and Calor (2017) listed a total of 155 genera and 3,262 extant species for this region.

Non-specialists know Trichoptera better by their larvae than their adults, especially because of the portable cases and fixed shelters that many larvae construct using silk. Larvae can be found in a large range of freshwater habitats, with a few species living in coastal marine waters (Riek 1976) and even in terrestrial habitat such as wet leaf litter (Anderson 1967, Nozaki 1999). Within these aquatic environments, they also exploit a high diversity of microhabitat, displaying a wide variety of life-history strategies, which can be mostly attributed to the diverse way through which silk is used (Mackay and Wiggins 1979, Wiggins 1996, 2004). Caddisfly larvae play important roles in freshwater biology, and they are essential components in ecological studies or water-quality assessment (Rosenberg and Resh 1993, Wiggins 1996). In the Neotropics, such kind of studies are still a challenge, since progress in larval taxonomy in last decades has been small. Pes et al. (2018) indicated that only 9.0% of Neotropical species have the immature stages described. Caddisfly taxonomy is mainly based on adult male like in most of insect orders, but our knowledge on their ecology and behavior are poorly known. Either in larval or adult stage, caddisflies are important components in riparian environments, as food resources for vertebrates and invertebrates, and possibly as pollinators (Flint et al. 1999).

Neotropical caddisfly fauna is clearly divided into two elements: the Chilean and Brazilian faunas, as defined by Flint et al. (1999), or the Patagonian and Neotropical faunas respectively, as proposed by de Moor and Ivanov (2008). Brazilian (or Neotropical) fauna occurs in southern Mexico, Central America, and most of South America except Chile. Chilean (or Patagonian) fauna occurs in Southern Chile and adjacent Argentina, and it has more similarity in taxonomic composition with the Australian and New Zealand faunas than with the Brazilian fauna. Several areas in Neotropical Region are characterized by high number of endemic taxa, like the Greater Antilles, the northern Andes, the Amazon basin, and mountainous areas of south and southeastern Brazil (Flint et al. 1999, Holzenthal and Calor 2017).

Brazil has the largest territory of all South American countries and hosts six biomes (Fig. 1), two of them mentioned as biodiversity "hotspots" due to the severe loss of habitat and the high concentration of endemic plants and vertebrates: Atlantic Forest and Cerrado (Myers et al. 2000). Although caddisfly diversity in South America is still poorly known, endemic genera and species of caddisflies are known to occur in mountainous areas of Atlantic Forest. Amazon Forest also concentrate a high number of endemic taxa, the same being true to caddisfly taxa. Although the Amazon forest is not listed as a global "hotspot" since the habitat loss is much more recent compared with Atlantic Forest and Cerrado, Amazon is currently under severe threat with rising deforestation rates (INPE 2019).

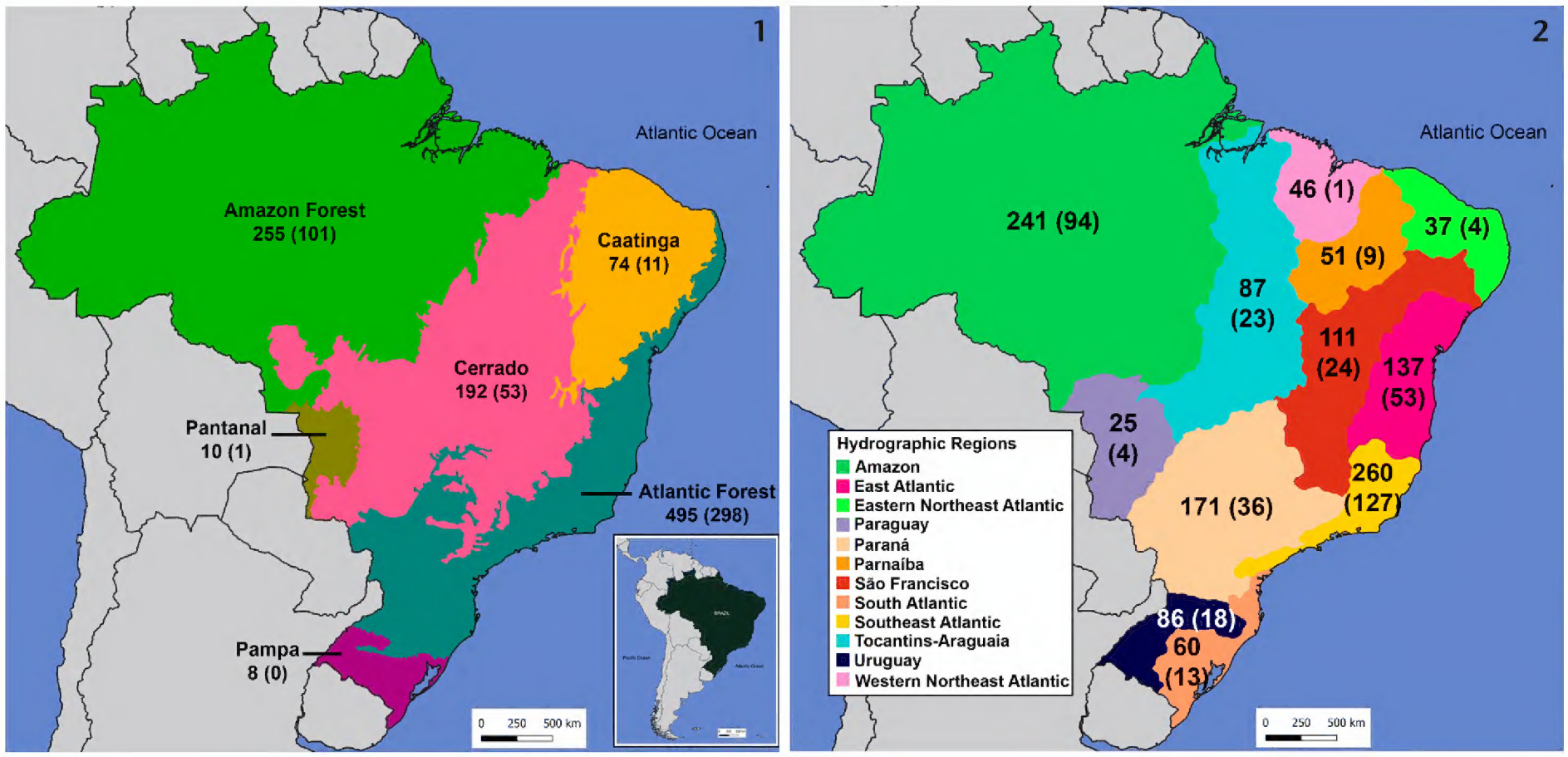
Caddisflies are aquatic insects and spend most of their life cycles in water. To study diversity and distribution of this insect order it is important to know the freshwater bodies of a particular region. Brazilian territory is divided into 12 hydrographic regions (Fig. 2) and holds approximately 12% of all freshwater resources available in the world with annual average of river flow of about 180 thousand m^3/s (ANA 2007, 2015). Unfortunately, most of Brazilian water bodies suffer with discharge of untreated sewage and with the advance of farming frontiers.

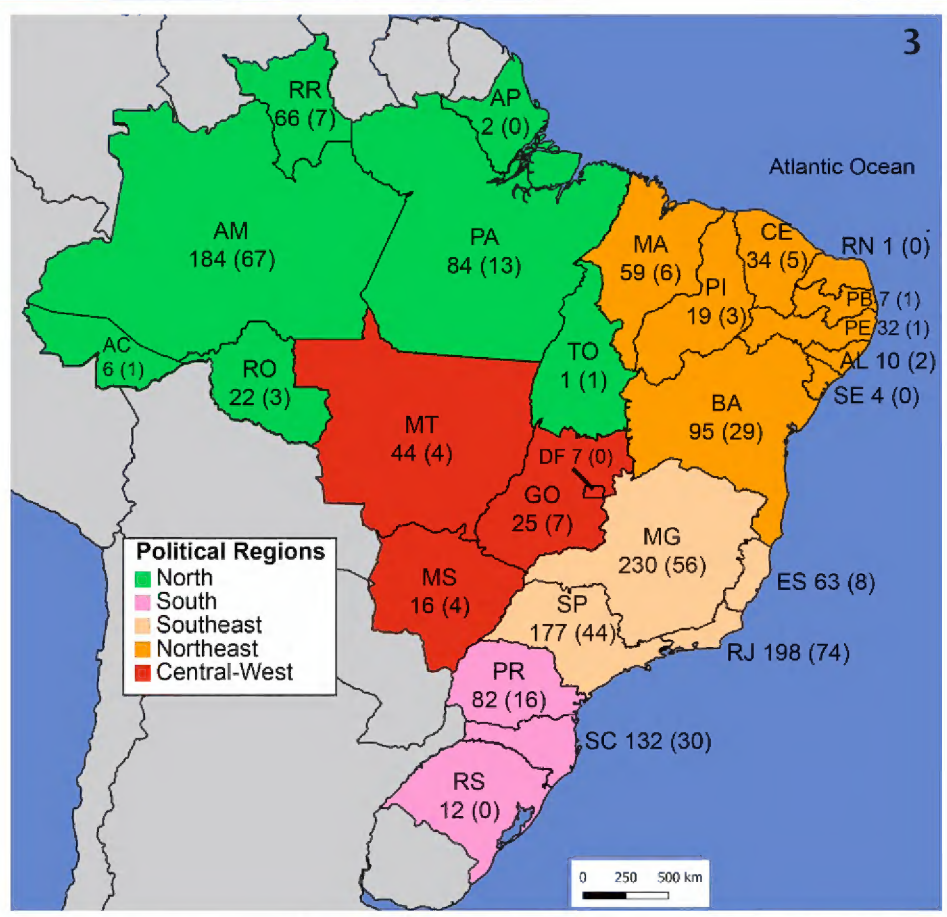
Taxonomic Catalog of the Brazilian Fauna

The Taxonomic Catalog of the Brazilian Fauna (in Portuguese: Catálogo Taxonômico da Fauna do Brasil – CTFB) is a project started in 2015, which now counts with participation of more than 500 zoologists, experts on taxonomy of different animal groups. In December 2016, first results of this project were made available: an on-line checklist of all animal species recorded from Brazilian territory. Since then, species lists have been constantly updated by researchers and more detailed information has been provided for each species such as a complete synonymic list, references, distributional data by region, state, biome, and hydrographic basin. All this information can be freely accessed on: http://fauna.jbrj.gov.br/fauna/listaBrasil. Brazil is a megadiverse country and for most of animal groups, specially arthropods, we certainly know only a fraction of the species occurring in the country, so building such database is not trivial.

The Trichoptera team working from the beginning of the project consists of seven Brazilian taxonomists, the authors in this paper. Since checklists and catalogs including caddisfly fauna from Brazil were already published elsewhere (e.g. Neotropical Catalogs: Flint et al. 1999 and Holzenthal and Calor 2017; checklists: Blahnik et al. 2004, Paprocki and França 2014), we used these as initial data sources, recovering detailed information from original papers addressing each species. As a result, we provided a constantly up to date taxonomic list for Brazilian caddisfly fauna, also including for each species hierarchy classification, synonymic list, distribution for Brazilian biomes (Fig. 1), hydrographic regions (Fig. 2), and states (Fig. 3), and bibliographic references. Additional data, for example type locality and depository, voucher information, links to other databases are already being inserted in the CTFB, but this will be made public only in future versions.

The database is available for public search in its updated on-line version (CTFB website), providing the following information: (1) taxonomic status of the name; (2) taxonomic hierarchy; (3) taxa included; (4) synonymic list; (5) if native from Brazil; (6) if endemic to Brazil; (7) geographic distribution in Brazil; (8) references recording the taxon in Brazil. The data used here (until August 2019) is provided in Suppl. S1 and an updated version of this spreadsheet is available upon request to corresponding author. We believe all this information, such as previous checklists and catalogs, will make easier to investigate the taxonomic diversity of caddisflies in Brazil and we also hope this will stimulate more research on this group in our country. The database is also relevant because it shows us through precise





Figures 1–3. Map of Brazil in South America showing: (1) the six continental biomes following IBGE (2004); (2) the twelve hydrographic regions in the country following ANA (2015); (3) the 26 states plus the Federal District. For each geographic unity, the respective number of caddisfly species, total and endemic, is provided.

numbers, priority areas and taxonomic groups to focus new collecting effort and research. Here, we used the database to estimate the total number of species to occur in Brazil and the similarity among biomes and hydrographic basins.

Brief historic of caddisfly taxonomy in Brazil

Caddisfly taxonomy in Brazil started with Josef A. Maximilian Perty, a German naturalist who published a series of works called "Insecta Brasiliensia" (1830–1834), including the first Brazilian caddisfly species in 1833 (also the first from Neotropics): *Phryganea maculata*, currently *Macrostemum brasiliense* (Fischer, 1970) (Fig. 4). Later in 19th century others described about a dozen of Brazilian caddisflies species (e.g. Pictet 1836, Burmeister 1839, Brauer 1865, McLachlan 1871). Early in 20th century, Ulmer (1913) provided the first checklist of Neotropical caddisflies, listing 162 species, 60 recorded from Brazil. Following that, several authors

(e.g., Banks, Müller, Navás, Ulmer) described and recorded many genera and species for the country (e.g. Figs 4–7), notably Johann Friederich Theodor Müller, a German naturalist who lived most of his life in Santa Catarina, Southern Brazil. Fritz Müller (as he is widely referred) worked as a travelling naturalist for the National Museum, in the city of Rio de Janeiro, Rio de Janeiro State, Brazil, although he never lived in this city. During his life in Santa Catarina, Fritz Müller had continuous correspondence with Charles Darwin and described many invertebrate species in about 250 publications, including 21 Brazilian caddisflies. Sadly, specimens studied by Fritz Müller, mainly larval cases, were lost in the devasting fire that destroyed most of the entomological collection in the National Museum in September 2018.

At second half of 20th century, the knowledge of Brazilian caddisfly fauna increased considerable due to the work of Dr Oliver S. Flint Jr (National Museum of Natural History, Smithsonian Institution, USA). Dr Flint Jr produced more than a hundred works on Neotropical fauna of Trichoptera, including many taxonomic and revisional publications of entire families and genera, and described more than 200 species from Brazil. Another important group of trichopterologists responsible for important contributions to Brazilian caddisfly taxonomy is that headed by Dr Ralph Holzenthal and Dr Roger Blahnik. Holzenthal, Blahnik, and their collaborators have described more than 150 species for the country, in addition to performing dozens of revisionary works.

After Fritz Müller (who was German-Brazilian), the first Brazilian to describe a caddisfly species was Dr Angelo Machado, despite being a dragonfly specialist. He described a snail-case caddisfly for the state of Minas Gerais – *Helicopsyche planorboides* Machado, 1957. It was only in 2002, almost 50 years later that another Brazilian described Brazilian caddisfly species, Dr Gisele Almeida and Dr Oliver S. Flint Jr with five species of *Smicridea* McLachlan, 1871 (Hydropsychidae) from the Southeast Brazil (Almeida and Flint 2002). Today, the current number of caddisfly taxonomists working and residing in Brazil has increased, although we are still far from an adequate number.

MATERIAL AND METHODS

Taxonomic information that fed CTFB was obtained from published papers with original descriptions, taxonomic revisions, checklists, and inventories, and only if species level identification was provided. Main resources for initial search were the Neotropical Catalogs (Flint et al. 1999, Holzenthal and Calor 2017). Detailed information was obtained for each caddisfly species described or reported for Brazil: author, year of description, synonyms, complete literature, year of first record in Brazil, if endemic to Brazil, and the distribution in biomes, hydrographic regions, and Brazilian states. Equivocal records and non-taxonomic papers with distributional data of species or superior taxa were not included. Species described or recorded from Brazil, with unknown precise distribution are included in the list, but with no distribution by biome, hydrographic region or state assigned.

Geographic distributional data are organized in three datasets: biomes (Fig. 1), as defined by the Brazilian Institute of Geography and Statistics (IBGE 2004); hydrographic regions (Fig. 2), as defined by National Water Agency (ANA 2015); and political division in states plus the Federal District (Fig. 3). For each species, all taxonomic papers available were analyzed to obtain the complete distribution in the three geographic levels. To assign species to biomes and hydrographic regions more precisely, or when the paper describing or recording the species was not clear about the location, we plotted geographic coordinates of material examined (if available) into Google Earth software. Maps of each hydrographic region with political divisions (states and municipalities) provided by ANA were also used to check or confirm species distribution. All data available were than inserted in Excel spreadsheets and also in the CTFB website. For each geographic level, plus the whole country, the number of endemic species is provided.

To generate species accumulation curve, the cumulative number of described species was plotted against the year of descriptions or the year of first record in Brazil, if this occurred only in subsequent papers. To evaluate the participation of Brazilian researchers in describing caddisfly species from the country, first authors of all species recorded were divided into four classes, according with their nationalities: Brazil, Canada and U.S.A., Europe, and Latin America-except Brazil. The nationality was used irrespective to the country that the researcher was in fact working. For Fritz Müller (German-Brazilian), nationality was assigned as German. An accumulation curve was then calculated based on classes of nationalities. In this case, year of species description was used regardless if it was originally described from Brazil or recorded latter.

Distribution of caddisfly species through biomes, hydrographic regions, and states were used, as distinct datasets, to estimate the number of unknown species in the country using non-parametric estimators. Estimators were calculated based on incidence data (presence-absence only), using biomes, hydrographic regions, and states as sampling unities, with the function specpool from vegan package (Oksanen et al. 2019) in software R (R Core Team 2019). This function calculates four estimators: CHAO2, first order jackknife (JACK1), second order jackknife (JACK2), and bootstrap (BOOT). These non-parametric estimators of species richness are useful to estimate a potential number of unobserved species based on incidence data as those available here and they have shown better performance than model-based or asymptotic estimators (Palmer 1990, Hortal et al. 2006).

Cluster analyses with unweighted pair-group method using arithmetic averages (UPGMA) were carried out in PAST version 3.22 (Hammer et al. 2001) for each geographic level (biomes, states, and hydrographic regions) using the Jaccard dissimilarity index. Since in the three datasets most of species

Figures 4–7. Adults of Brazilian caddisflies: (4) *Macrostemum brasiliense* (Fisher, 1970), the first caddisfly species described from Brazil, originally as *Phryganea maculata* Perty, 1833 (photo by FF Salles), Espirito Santo state; (5) *Centromacronema auripenne* (Rambur, 1842), a problematic taxon with several synonyms and in need of a taxonomic revision, Rio de Janeiro state; (6) *Nectopsyche* sp., an unidentified species of this diverse and poorly studied genus, Rio de Janeiro; (7) *Marilia* sp., an unidentified species of another genus in need of taxonomic revision, Amazonas.

were represented in only a single region, those species were excluded prior cluster analyses to minimize effect of species richness differences on dissimilarity values. 10,000 bootstrap pseudoreplicates were used to evaluate cluster support.

RESULTS

A total of 796 species of Trichoptera were recorded to Brazil until August 2019 (Table 1), from which 538 (68%) are endemic to the country. Atlantic Forest is the biome with highest number of known species (495) followed by Amazon Forest (255), and then Cerrado (192), Caatinga (74), Pantanal (10), and Pampa (8). Atlantic Forest also presents the highest proportion of endemic species, with 298 endemic species, 60% of its species, whereas Amazon Forest has 40% with 101 endemic species (Fig. 1, Suppl. S2). Concerning the hydrographic regions, the largest one, the Amazon Hydrographic Region, which occupies 45% of Brazil-

Table 1. Numbers of described species of the five aquatic insect orders from Brazil and from the World, and the percentage of Brazilian fauna in relation to the World for each order.

	Brazil	World	Brazil/World (%)
Trichoptera	796	16,266[a]	4.9
Odonata	867[b]	6,321[c]	13.7
Ephemeroptera	398[d]	5,030[e]	7.9
Plecoptera	164[f]	3,800[g]	4.3
Megaloptera	18[h]	328[i]	5.5

Sources: a) Morse et al. 2019, b) Pinto 2019, c) Schorr and Paulson 2019, d) Salles and Boldrini 2019, e) Kluge 2019, f) Lecci 2019, g) DeWalt et al. 2019, h) Rafael and Câmara 2019, i) Dijsktra et al. 2014.

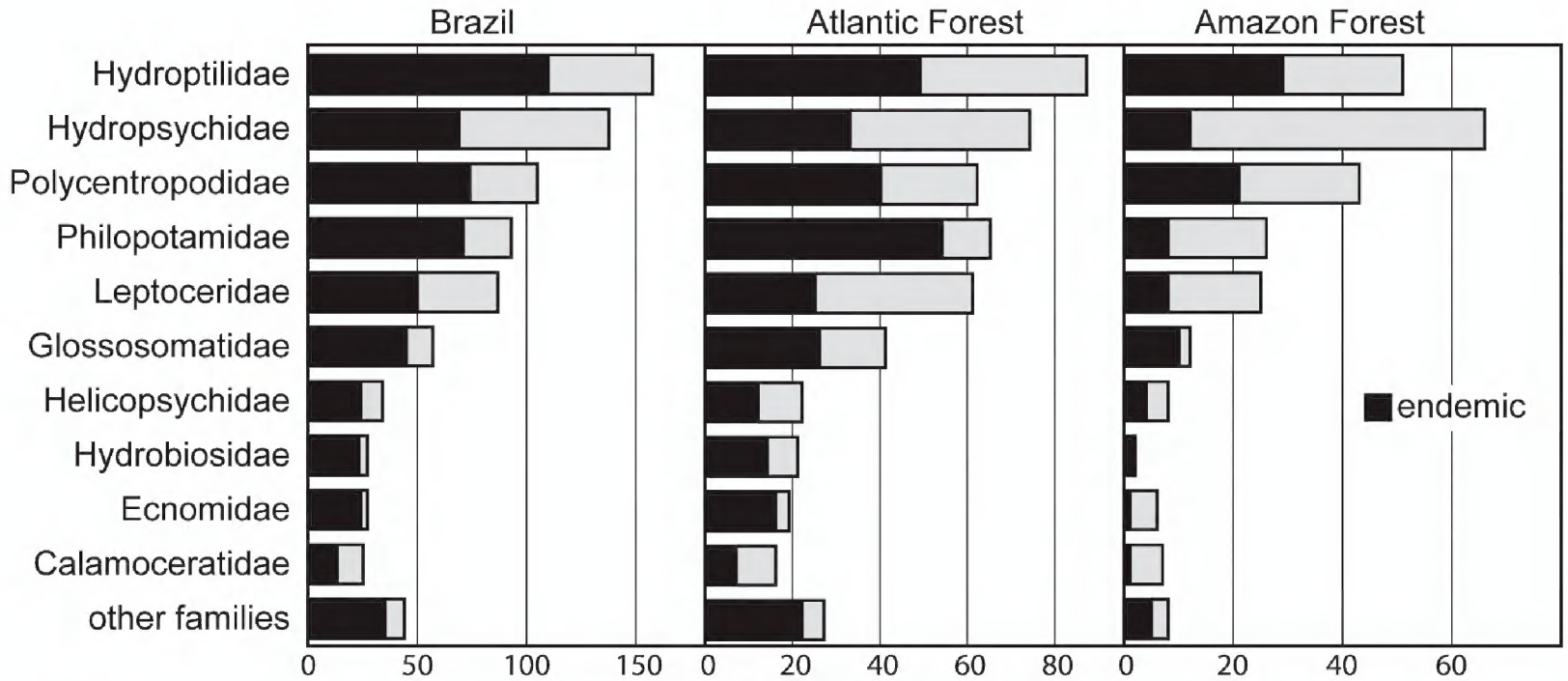


Figure 8. Contribution of the ten most diverse caddisfly families to the total richness of Trichoptera in Brazil, in Atlantic Forest, and in Amazon Forest, respectively, indicating the proportion of endemic species for each family in each area.

ian territory, has 241 caddisfly species recorded (94 endemic), whereas the Southeast Atlantic Hydrographic Region, with an area nearly 18 times smaller, has 260 (127 endemic) (Fig. 2, Suppl. S3). Minas Gerais and Rio de Janeiro (Southeastern Region) are the states with more species records, respectively with 230 and 198, followed by Amazonas (Northern Region) with 184 (Fig. 3, Suppl. S4).

Hydroptilidae were the most diverse family in the country with 158 species (20% of caddisfly species in the country), followed by Hydropsychidae with 138 (17%), Polycentropodidae with 105 (13%), Philopotamidae with 93 (12%), and Leptoceridae with 88 (11%) (Fig. 8). Among these five most diverse families, proportion of endemic species ranges from 51% in Hydropsychidae to 76% in Philopotamidae. Philopotamid species show a higher proportion of endemism in Atlantic Forest, where 83% of the species in this family are endemic to this biome (Fig. 8).

Since the first Brazilian species described in 1833, the average rate of description by year is 4.26 species. In the last two decades, the average rate rises from 11.1 species/year (1999–2008) to 34.8 species/year (2009–2018). The peak of species description (or geographic records) from Brazil was in 2011, when 77 species were newly reported (both new species and new distributional records) to the country (Fig. 9). The accumulation curve of species per year shows a significant rise in rates of caddisfly records in Brazil from 1960 onwards (Fig. 10). Authors from the U.S.A. were responsible for most of the Brazilian species known so far, and they have named 385 species (as first authors), of which, 188 were described and named by Dr Oliver S. Flint Jr (as first author). In recent years, participation of Brazilians in caddisfly descriptions is growing fast (Fig. 11), and until now 236 species have been named by Brazilians as first authors. Accumulation curve based on first author origin (Fig. 11) shows a more stabilized curve to European authors;

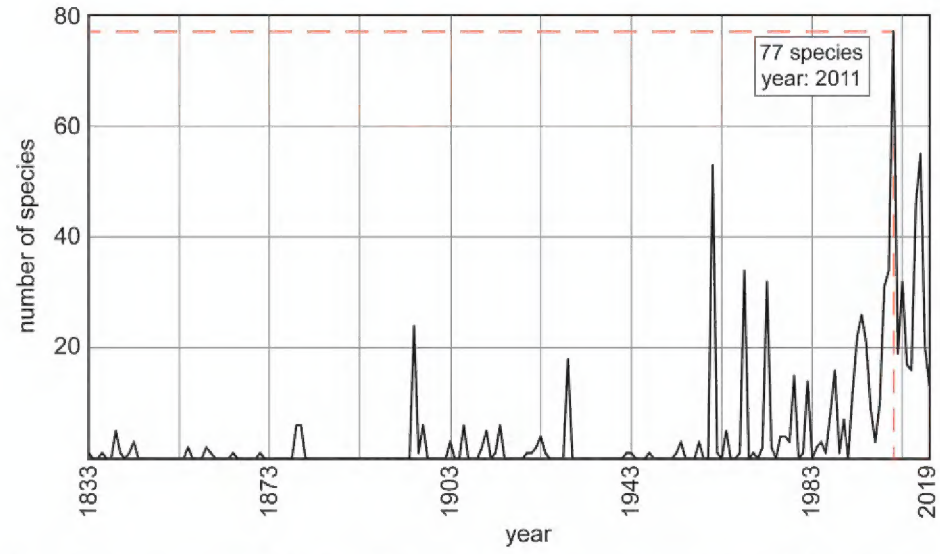
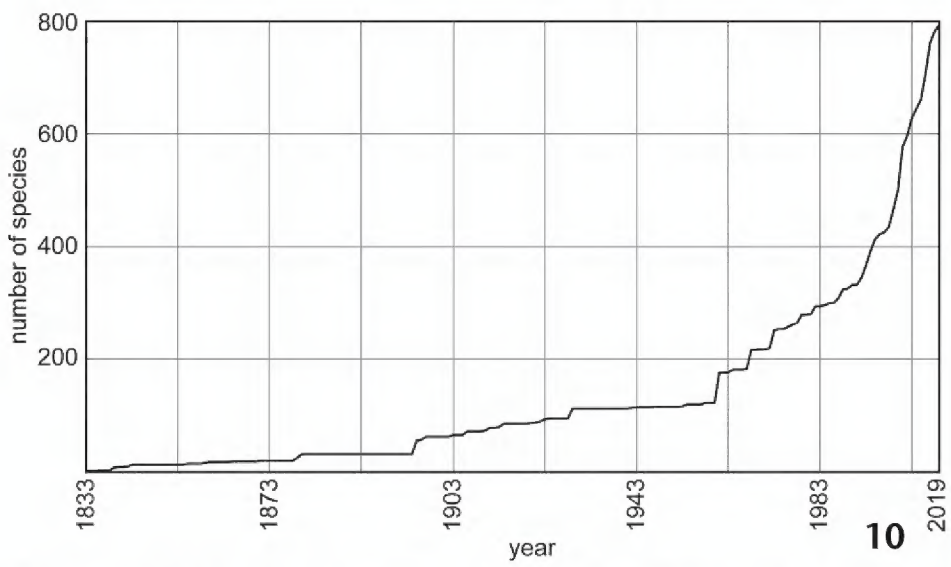


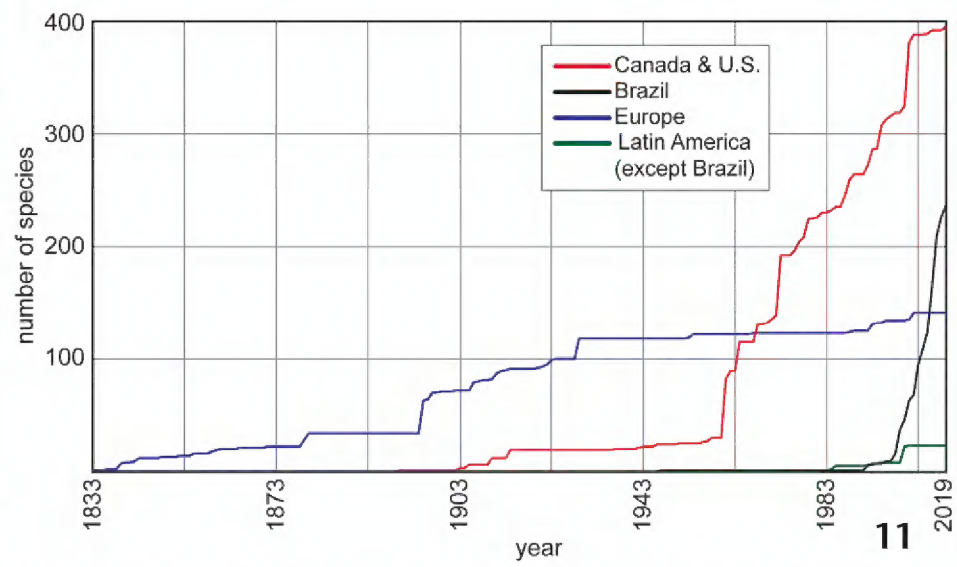
Figure 9. Number of caddisfly species described or reported to Brazil by year (from 1833 to July 2019).

Canadian and U.S.A. authors with a strong upward tendency starting about 1965; and Brazilian authors with a curve growing much more recently (from year 2000), but with a very strong upward tendency.

Estimators of species richness predicted slightly different numbers for potential diversity in Brazil, with BOOT always indicating the lowest ones and CHAO2 indicating the highest ones (Table 2). CHAO2 also showed the highest difference among estimates with different datasets (Table 2). Since JACK2 showed a good behavior throughout permutations using the function poolaccum from the vegan package (low variance in estimates with subsets) with the three datasets and the three values are very close to each other, this estimator was preferred over the others. JACK2 indicates 1,586–1,644 caddisfly species to Brazil (Table 2).

Regardless the geographic unity used (biomes, hydrographic regions, or states), areas were very dissimilar and cluster analyses based on Jaccard dissimilarities revealed only very weak groups (Fig. 12, Suppl. S5). However, cluster analysis with hydro-





Figures 10–11. Accumulation curves of caddisfly species described or reported to occur in Brazil by year (from 1833 to July 2019): (10) total; (11) considering the citizenship of the first author of the species name.

Table 2. Number of observed species (Nobs) of Brazilian caddisfly recorded by biome, hydrographic region, and states with estimated richness by CHAO2, first order jackknife (JACK1), second order jackknife (JACK2), and bootstrap (BOOT) respectively obtained for each dataset, with respective standard errors (SE). Total number of samples unities for each geographic level is indicated by n. Values were calculated with specpool function from vegan package in R, which does not calculate standard error for Jack2.

	Nobs*	CHAO2	CHAO2 SE	Jack1	Jack1 SE	Jack2	Boot	Boot SE	n
Biomes	787	2,085.20	161.88	1,298.67	372.01	1,643.47	1,003.81	192.11	6
Hydrographic regions	784	1,633.58	106.26	1,262.50	214.33	1,586.14	986.01	106.86	12
States	793	1,673.79	115.88	1,257.15	162.14	1,590.38	986.39	88.21	27

*Total number of species recorded from Brazil is 796, but distributional information is incomplete for some of them.

graphic regions recovered two groups: one with northern hydrographic regions (Eastern Northeast Atlantic, Tocantins-Araguaia, Parnaíba, Western Northeast Atlantic, Amazon, and Paraguay) and another with southern regions (Paraná, Southeast Atlantic, São Francisco, East Atlantic, South Atlantic, and Uruguay). Clusters formed in this analysis were consistent with geographic proximity among hydrographic regions (Fig. 12).

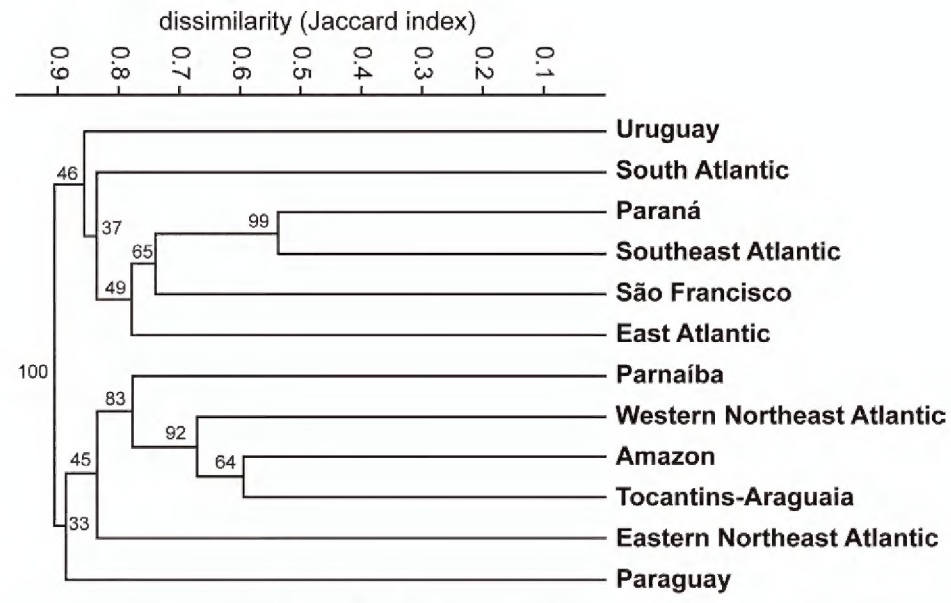


Figure 12. Unweighted pair-group average (UPGMA) dendrogram based on Jaccard dissimilarity index of the incidence data of Trichoptera in Brazilian hydrographic regions. Species recorded only in one region were removed from the analysis. Values near branches are bootstrap analyses with 10,000 pseudoreplicates. Dendrogram and bootstrap values were calculated in software PAST.

DISCUSSION

Progress in Brazilian caddisfly taxonomy

The first caddisfly described from Brazil dates from 1833, 75 years after publication of the Tenth Edition of Systema Naturae (Linnaeus 1758) and the beginning of modern zoology taxonomy. Due to politic and historic issues, in the 19th century, naturalists from Europe were responsible for almost all descriptions of caddisflies from Brazil. Peaks of species descriptions in the second half of the 20th century, as shown in Fig. 9, correspond to massive works of Dr Oliver S. Flint Jr in South America, with special attention to the Amazon Region (e.g. Flint 1971, 1978, 1998). By the end of the 20th century and beginning of the 21th century, Dr Ralph Holzenthal, Dr Blahnik, and collaborators were responsible for most species descriptions. Except for F. Müller, Dr Angelo Machado was the first Brazilian to describe a caddisfly, in 1957. But it was only after the year 2000 that publications from researchers working in the country started to proliferate, and now we can notice a strong upward trend in accumulation curve of species described by Brazilians (Fig. 11). It is noteworthy that Dr Jorge Nessimian contributed naming 108 species so far, and still working and advising new students on caddisfly taxonomy.

Trichoptera are one of the most diverse group among aquatic insects. Despite this, taxonomic diversity in the World remains poorly studied (Dijkstra et al. 2014). In Brazil, with more intense participation of Brazilians in studying the taxonomy of caddisfly, our knowledge about the fauna increased rapidly in recent years, going from 378 species listed in the checklist provided by Paprocki et al. (2004) to 796 today. This means that more than half of the species known to Brazil were described in the last 14 years. In this way, grants and fellowships directed to researchers working on taxonomic projects were very important to promote caddisfly taxonomy in Brazil.

In current numbers, Brazilian caddisfly fauna represents less than 5% of the world diversity of Trichoptera species (Table 1). Among aquatic insect orders, this percentage is higher only than Plecoptera (4.3%). Based on caddisfly distribution throughout Brazilian states, JACK2 estimated 1,588 species to the country, almost twice the current number of known species. Assuming this estimation is close to reality, this value would correspond to about 10% of the world caddisfly fauna. Compared with well-studied groups, this is still a low number, for example, Odonata are represented in Brazil by 867 species, almost 14% of the global odonatan fauna. An even higher number for caddisfly diversity in Brazil was predicted by Paprocki (2012), around 3,000 species, but this was not based on statistical analyses. Accumulation curve of described species shows a strong upwards trend in the last years (Fig. 10), which indicates that there is much more species to be described to reach the real caddisfly diversity in Brazil. Ríos-Touma et al. (2017) listed 310 caddisfly species to Ecuador and estimated 578 with CHAO 2 estimator. Since Brazilian territory occupies most of South America and encompasses areas of high diversity and concentration of endemism such as Amazon Forest, Atlantic Forest, and Cerrado, it will not be surprising if the actual number exceeds 2,000 species.

Most diverse families

Hydroptilidae are the most diverse family in Brazil with 158 species and many more species remain to be described, the same for the rest of the world's fauna. In Brazil, 22 genera are recorded and only a few of these were focus of recent taxonomic papers (e.g. Wasmund and Holzenthal 2007, Thomson and Holzenthal 2015, Santos et al. 2016a, b, Souza and Santos 2017, Thomson 2019) (Suppl. S6). More than a third of the species in the family is in Neotropical Region (Morse et al. 2019) and they are usually neglected by caddisfly workers due to their small sizes (in general less than 5.0 mm), resulting in many unsorted or unidentified specimens in collections. For this reason, it is common to find high number of new species when examining caddisfly samples in collections or when collecting new material in Brazil. Even historically well studied areas in Brazil, as the Southern region, usually reveal a high number of hydroptilid new species. In this family, genera with many species in collections waiting to be named are *Alisotrichia* Flint, 1964, *Flintiella* Angrisano, 1995, *Hydroptila* Dalman, 1819, *Neotrichia* Morton, 1905, and *Oxyethira* Eaton, 1873.

The second most diverse family in the country is Hydropsychidae with 138 species (in 9 genera), over a third of them in the speciose genus *Smicridea* (55). Despite the apparently high number, many more undescribed species of *Smicridea* from Brazil are sitting in collections, but the genus needs a careful taxonomic revision to clarify the identity and boundaries of its taxonomic units. Another complex group of hydropsychid genera are *Centromacronema* Ulmer, 1905 and *Macronema* Pictet, 1836. Both genera are endemic to the Neotropical Region and their adults usually have brightly colored wings (Holzenthal and Calor 2017). Since these colored adults are also large and mostly day active, many *Centromacronema* and *Macronema* species were already described in the 19th century or the beginning of the 20th century (Holzenthal and Calor 2017). Although some species have been described recently, identity of several older names are unclear (Holzenthal and Calor 2017). Among the Neotropical hydropsychids, certainly these two genera are the ones that most need taxonomic revisions (Suppl. S6), with a careful re-examination of each type specimen available. *Leptonema* Guérin-Méneville, 1843 and *Macrostemum* Kolenati, 1859 are other two diverse Hydropsychidae genera in Brazil, respectively with 32 and 17 species recorded. However, for these two world distributed genera, taxonomic revisions are available. For *Leptonema*, a revision for the whole genus was published (Flint et al. 1987) and for *Macrostemum*, a review including all Neotropical species (França et al. 2013).

Leptocerids are the second most speciose caddisfly family in the world with more than 2,000 known species (Morse et al. 2019). In Brazil, the number of described species of Leptoceridae (88) is smaller than Polycentropodidae (105) and Philopotamidae (93). However, the diversity of leptocerids is poorly explored in Brazil, and in Neotropics as a whole, mostly because two large genera, *Nectopsyche* Müller, 1879 and *Oecetis* McLachlan, 1877, were not recently revised and likely include much more species than current numbers. On the other hand, Polycentropodidae and Philopotamidae genera were focus of recent taxonomic works (see Suppl. S6). For example, the recently described genus *Alterosa* Blahnik, 2005 was established in 2005 to include two previously known species and several new ones. Now it includes 39, all of them restricted to mountainous areas of Atlantic Forest in Brazil (Blahnik 2005, Dumas and Nessimian 2013, Dumas et al. 2013). Although, even for those revised genera undescribed species are still being discovered and it is likely that leptocerids, along with hydroptilids and hydropsychids, correspond to the three more speciose families in Brazil.

Distribution of caddisflies in Brazil

Information about distribution of living organisms are usually biased due to unequal pattern of collecting effort (the "Wallacean shortfall" – Hortal et al. 2015) and caddisflies are not an exception. Despite the increase of published taxonomic papers in recent years on Brazilian caddisfly fauna, the distribution of caddisflies in Brazil still reflects areas of higher concentration

of research centers, in the Southeastern and Northern regions. As a result, more than half of the recorded species from Brazil occurs in the Atlantic Forest (495 of total 796 species) and the Amazon Forest is the second biome in number of species (255).

The Neotropical Region shows a high number of endemic caddisfly taxa and, in terms of number of endemic genera, it is surpassed only by the Australasian Region (de Moor and Ivanov 2008). The high number of endemic caddisfly taxa to Brazil is not surprising. Despite the uneven collecting effort, endemism of caddisfly fauna in Atlantic Forest is remarkably high with about 60% (298) of species recorded being endemic, a proportion much higher compared with vertebrates or plants (about 40%, Myers et al. 2000). As typical for tropical mountains, which quite often house many endemic species (Steinbauer et al. 2016), Atlantic Forest mountains in Southeastern Brazil show high numbers of caddisfly species richness, with several endemic taxa (Dumas and Nessimian 2012, Henriques-Oliveira et al. 2018). Among these endemic taxa we can highlight *Antarctoecia brasiliensis* Huamantinco & Nessimian, 2003 and *Neoatriplectides desiderata* Dumas & Nessimian, 2008, respectively the only Limnephilidae and Atriplectididae species to occur in Brazil, both families typically represented in South America by Andean species.

Among the top five most diverse families, philopotamids have relatively higher proportion of endemic species in Atlantic Forest, with 83% of the recorded species being endemic to this biome. As mentioned above, Philopotamidae are represented in the Atlantic Forest by *Chimarra* Stephens, 1829 and by the endemic genus *Alterosa*. Since the Atlantic Forest is one of the most threatened biomes in the World (Myers et al. 2000, Mittermeier et al. 2004), and currently only about 12% of its natural area remains (Ribeiro et al. 2011), knowing better the distribution of these endemic taxa are extremely important to the conservation of our biodiversity.

Since there has been an unbalanced collecting effort, with most of taxonomic studies on Brazilian caddisfly being limited to Amazon and Atlantic forests, comparing composition among biomes or hydrogeographic regions is not easy. Although most groups of clustering analysis had weak support, dissimilarity among hydrographic regions indicate two groups, one with northwestern regions (Amazon, Tocantins-Araguaia, Paraguay, Western Northeast Atlantic, Parnaíba, and Eastern Northeast Atlantic) and another with southeastern regions (São Francisco, East Atlantic, Southeast Atlantic, South Atlantic, Uruguay, and Paraná) (Fig. 12). These groups are interesting in a biogeographic point of view because they could represent a disjunction between an Amazonian and an Atlantic Forest faunas. The Amazon and the Atlantic forests are separated by a dry corridor, the South American dry diagonal, comprising the Chaco, Cerrado, and Caatinga biomes (Ab'Saber 1977). Several studies have indicated past connections between these two Neotropical forests (e.g. Costa 2003, Sobral-Souza et al. 2015). However, formation of this drier area separating Amazonia from Atlantic Forest over the evolutionary time could be a relevant factor to explain current distribution of caddisfly species throughout the Brazilian biogeographic component.

The Brazilian Cerrado occupies a larger area than the Atlantic Forest, about half of the Brazilian Amazon area (Suppl. S2), and it is also a world biodiversity hotspot (Myers et al. 2000). On the other hand, the Caatinga is slightly smaller than the Atlantic Forest and usually associated with low number of species. Caddisfly diversity in the Caatinga and Cerrado was only poorly studied, but recent works on these dry biomes have revealed high numbers (Costa et al. 2014, Quinteiro et al. 2014, Takiya et al. 2016, Henriques-Oliveira et al. 2018). Surveys on caddisflies from the Caatinga and Cerrado are crucial and increasingly needed to understand the effect of the dry corridor as a potential barrier to aquatic insects during the formation of South American forested biomes. Based on this, biogeographic and phylogeographic studies using refined data of caddisfly taxa have potential to reveal insights about the complex events related to the formation of Neotropical biomes.

ACKNOWLEDGEMENTS

Since this paper was submitted for publication, 16 caddisfly species have been described or reported from Brazil bringing the total number to 812. We thank Aliny Pires (UERJ) for suggestions during the planning of this paper. We thank Ralph Holzenthal, Adriano S. Mello and an anonymous reviewer for valuable comments and suggestions on this paper. We are very grateful to the Coordinators of CTFB: Walter A.P. Boeger (UFPR), Hussam Zaher (MZUSP), José Albertino Rafael (INPA), and Michel P. Valim (MZUSP) for management of this enormous project, and especially José A. Rafael for inviting us to collaborate with Trichoptera. We thank Frederico F. Salles for allowing us to use the photo of *Macrostemum brasiliense*. APMS thanks Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) for financial support (Universal-proc. 403792/2016-9). The authors revised the manuscript and are responsible for its content, including any improprieties in use of the English language.

LITERATURE CITED

Ab'Saber A (1977) Os Domínios Morfoclimáticos da América do Sul: Primeira Aproximação. Geomorfologia. 52: 1–21.

Agência Nacional de Águas, ANA (2007) GEO Brazil, Water Resources: Component of a Series of Reports on the Status and Prospects for Environment in Brazil, Executive Summary. United Nations Environment Programme, Brasília, 60 pp.

Agência Nacional de Águas, ANA (2015) Conjuntura dos Recursos Hídricos no Brasil: regiões hidrográficas brasileiras. Agência Nacional de Águas, Brasília, 163 pp. Available at: http://www.ana.gov.br

Almeida GL, Flint OS Jr (2002) Five new species of *Smicridea* McLachlan (Trichoptera, Hydropsychidae) from Brazil. Revista Brasileira de Zoologia 19: 767–775. https://doi.org/10.1590/S0101-81752002000300014

Anderson NH (1967) Life cycle of a terrestrial caddisfly, *Philocasca demita* (Trichoptera: Limnephilidae) in North America. Annals of the Entomological Society of America 60: 320–323. https://doi.org/10.1093/aesa/60.2.320

Blahnik RJ (2005) *Alterosa*, a new caddisfly genus from Brazil (Trichoptera: Philopotamidae). Zootaxa 991: 3–60.

Blahnik RJ, Paprocki H, Holzenthal RW (2004) New distribution and species records of Trichoptera from southern and southeastern Brazil. Biota Neotropica 4: 1–6. https://doi.org/10.1590/S1676-06032004000100009

Brauer F (1865) Zweiter bericht uber die auf der Weltfahrt der kais. Fregatte Novara gesammelten Neuroptera. Verhandlungen der Kaiserlich-Königlichen Zoologischen-Botanischen Gesellschaft in Wien 15: 415–422.

Burmeister H (1839) Handbuch der Entomologie, Zweiter Band, Zweite Ubtheilung. Theod. Chr. Friedr. Enslin, Berlin, xii + 397–1050 pp.

Costa LP (2003) The historical bridge between the Amazon and the Atlantic Forest of Brazil: a study of molecular phylogeography with small mammals. Journal of Biogeography 30: 71–86. https://doi.org/10.1046/j.1365-2699.2003.00792.x

Costa AM, Quinteiro FB, Calor AR (2014) Trichoptera do Semiárido I: Annulipalpia. In: Bravo F, Calor A (Orgs). Artrópodes do Semiárido: biodiversidade e conservação. Printmídia, Feira de Santana, 225–228.

de Moor FC, Ivanov VD (2008) Global diversity of caddisflies (Trichoptera: Insecta) in freshwater. Hydrobiologia 595: 393–407. https://doi.org/10.1007/s10750-007-9113-2

DeWalt RE, Maehr MD, Hopkins H, Neu-Becker U, Stueber G (2019) Plecoptera species file online, version 5.0/5.0. Available at: http://Plecoptera.SpeciesFile.org

Dijkstra KDB, Monaghan MT, Pauls SU (2014) Freshwater biodiversity and aquatic insect diversification. Annual Review of Entomology 59: 143–163. https://doi.org/10.1146/annurev-ento-011613-161958

Dumas LL, Nessimian JL (2012) Faunistic catalog of the caddisflies (Insecta: Trichoptera) of Parque Nacional do Itatiaia and its surroundings in southeastern Brazil. Journal of Insect Science 12: 1–38. https://doi.org/10.1673/031.012.2501

Dumas LL, Nessimian JL (2013) New species of the caddisfly genus *Alterosa* Blahnik 2005 (Trichoptera: Philopotamidae: Philopotaminae) from Brazil. Zootaxa 3609: 26–48. https://doi.org/10.11646/zootaxa.3609.1.2

Dumas LL, Calor AR, Nessimian JL (2013) The genus *Alterosa* Blahnik 2005 (Trichoptera, Philopotamidae, Philopotaminae) in northeastern Brazil, including the description of three new species and an identification key for the genus. ZooKeys 317: 1–15. https://doi.org/10.3897/zookeys.317.5437

Flint OS Jr (1971) Studies of Neotropical caddisflies, XII: Rhyacophilidae, Glossosomatidae, Philopotamidae, and Psychomyiidae from the Amazon Basin (Trichoptera). Amazoniana 3: 1–67.

Flint OS Jr (1978) Studies of Neotropical Caddisflies, XXII: Hydropsychidae of the Amazon Basin (Trichoptera). Amazoniana 6: 373–421.

Flint OS Jr (1998) Studies of Neotropical caddisflies, LIII: a taxonomic revision of the subgenus *Curgia* of the genus *Chimarra* (Trichoptera: Philopotamidae). Smithsonian Contributions to Zoology 594: 1–131. https://doi.org/10.5479/si.00810282.594

Flint OS Jr, Holzenthal RW, Harris SC (1999) Catalog of the Neotropical Caddisflies (Trichoptera). Special Publication, Ohio Biological Survey, Columbus, Ohio, 239 pp.

Flint OS Jr, McAlpine JF, Ross HH (1987) A revision of the genus *Leptonema* Guerin (Trichoptera: Hydropsychidae: Macronematinae). Smithsonian Contributions to Zoology 450: 1–193. https://doi.org/10.5479/si.00810282.450

França D, Paprocki H, Calor AR (2013) The genus *Macrostemum* Kolenati 1859 (Trichoptera: Hydropsychidae) in the Neotropical Region: Description of two new species, taxonomic notes, distributional records and key to males. Zootaxa 3716: 301–335. https://doi.org/10.11646/zootaxa.3716.3.1

Hammer Ø, Harper DAT, Ryan PD (2001) PAST: Paleontological Statistics Software Package for Education and Data Analysis. Palaeontologia Electronica 4: 9.

Henriques-Oliveira AL, Rocha IC, Nessimian JL (2018) Leptoceridae (Insecta, Trichoptera) from Serra da Canastra Mountain Range, Southeast Brazil: Diversity, distribution, and description of two new species. Neotropical Entomology 48: 277–289. https://doi.org/10.1007/s13744-018-0633-4

Holzenthal RW, Calor AR (2017) Catalog of the Neotropical Trichoptera (Caddisflies). Zookeys 654: 1–566. https://doi.org/10.3897/zookeys.654.9516

Hortal J, Borges PAV, Gaspar C (2006) Evaluating the performance of species richness estimators: Sensitivity to sample grain size. Journal of Animal Ecology 75: 274–287. doi:10.1111/j.1365-2656.2006.01048.x

Hortal J, de Bello F, Diniz-Filho JAF, Lewinsohn TM, Lobo JM, Ladle LJ (2015) Seven Shortfalls that Beset Large-Scale Knowledge of Biodiversity. Annual Review of Ecology, Evolution and Systematics 46: 523–549. https://doi.org/10.1146/annurev-ecolsys-112414-054400

Instituto Brasileiro de Geografia e Estatística, IBGE (2004) Mapa de Biomas e de Vegetação do Brasil. Available at: http://www.ibge.gov.br/

Instituto Nacional de Pesquisas Espaciais, INPE (2019) TerraBrasilis, Deforestation Available at: http://terrabrasilis.dpi.inpe.br.

Kluge NJ (2019) Ephemeroptera of the World. Available at: http://www.insecta.bio.spbu.ru/z/Eph-spp/

Kristensen NP (1997) Early evolution of the Trichoptera + Lepidoptera lineage: phylogeny and the ecological scenario. Mémoires Museum National d'Histoire Naturelle 173: 253–271.

Lecci L (2019) Plecoptera. In: Catálogo Taxonômico da Fauna do Brasil. PNUD. Available at: http://fauna.jbrj.gov.br/fauna/faunadobrasil/304

Linnaeus C (1758) Systema Naturae per Regna tria Naturae, Secundum Classes, Ordines, Genera, Species, cum Characteribus, Differentiis, Synonymis, Locis. Stockholm, 10th Edition, vol. 1, 824 pp.

Machado ABM (1957) *Helicopsyche planorboides* n. sp. (Trichoptera Helicopsychidae) and its mimetic relationship to planorbids (Mollusca Pulmonata). Anais da Academia Brasileira de Ciências 29: 193–200.

Mackay RJ, Wiggins GB (1979). Ecological Diversity in Trichoptera. Annual Review of Entomology 24: 185–208. https://doi.org/10.1146/annurev.en.24.010179.001153

McLachlan R (1871) On new forms, etc., of extra-European Trichopterous insects. Journal of the Linnean Society of London, Zoology 11: 98–141. https://doi.org/10.1111/j.1096-3642.1870.tb02011.x

Misof B, Liu S, Meusemann K, Peters RS, Donath A, Mayer C, Frandsen PB, Ware J, Flouri T, Beutel RG, Niehuis O, Petersen M, Izquierdo-Carrasco F, Wappler T, Rust J, Aberer AJ, Aspöck U, Aspöck H, Bartel D, Blanke A, Berger S, Böhm A, Buckley TR, Calcott B, Chen J, Friedrich F, Fukui M, Fujita M, Greve C, Grobe P, Gu S, Huang Y, Jermiin LS, Kawahara AY, Krogmann L, Kubiak M, Lanfear R, Letsch H, Li Y, Li Z, Li J, Lu H, Machida R, Mashimo Y, Kapli P, McKenna DD, Meng G, Nakagaki Y, Navarrete-Heredia JL, Ott M, Ou Y, Pass G, Podsiadlowski L, Pohl H, von Reumont BM, Schütte K, Sekiya K, Shimizu S, Slipinski A, Stamatakis A, Song W, Su X, Szucsich NU, Tan M, Tan X, Tang M, Tang J, Timelthaler G, Tomizuka S, Trautwein M, Tong X, Uchifune T, Walzl MG, Wiegmann BM, Wilbrandt J, Wipfler B, Wong TKF, Wu Q, Wu G, Xie Y, Yang S, Yang Q, Yeates DK, Yoshizawa K, Zhang Q, Zhang R, Zhang W, Zhang Y, Zhao J, Zhou C, Zhou L, Ziesmann T, Zou S, Li Y, Xu X, Zhang Y, Yang H, Wang J, Wang J, Kjer KM, Zhou X (2014) Phylogenomics resolves the timing and pattern of insect evolution. Science 346: 763–767. https://doi.org/10.1126/science.1257570

Mittermeier RA, Gil PR, Hoffmann M, Pilgrim J, Brooks J, Mittermeier CG, Lamourux J, Fonseca GAB (2004) Hotspots revisited: earth's biologically richestand most endangered terrestrial ecoregions. Cemex, Washington, DC.

Morse JC, Frandsen PB, Graf W, Thomas JA (2019) Diversity and Ecosystem Services of Trichoptera. Insects 10: 125. https://doi.org/10.3390/insects10050125

Myers N, Mittermeier RA, Mittermeier CG, Fonseca GAB, Kent J (2000) Biodiversity hotspots for conservation priorities. Nature 403: 853–858. https://doi.org/10.1038/35002501

Nozaki T (1999) A new terrestrial caddisfly, *Nothopsyche montivaga* n. sp., from Japan (Trichoptera: Limnephilidae). Proceedings of the 9th International Symposium on Trichoptera, Chiang Mai, 299–309.

Oksanen J, Blanchet FG, Friendly M, Kindt R, Legendre P, Mcglin D, O'hara RB, Simpson GL, Solymos P, Stevens MHH, Szoecs E, Wagner H (2019) Vegan: Community Ecology Package. https://cran.r-project.org/web/packages/vegan

Palmer MW (1990) The estimation of species richness by extrapolation. Ecology 71: 1195–1198. https://doi.org/10.2307/1937387

Paprocki H (2012) Trichoptera Kirby, 1813. In: Rafael JA, Melo GAR, Carvalho CJB, Casari SA, Constatino R (Eds) Insetos do Brasil: diversidade e taxonomia. Holos Editora, Ribeirão Preto, 613–623.

Paprocki H, França D (2014) Brazilian Trichoptera Checklist II. Biodiversity Data Journal 2: e1557: 1–109. https://doi.org/10.3897/BDJ.2.e1557

Paprocki H, Holzenthal RW, Blahnik RJ (2004) Checklist of the Trichoptera (Insecta) of Brazil I. Biota Neotropica 4: 1–22. https://doi.org/10.1590/S1676-06032004000100008

Perty JAM (1830–1834) Insecta Brasiliensia. In: Martius KFP (Ed.) Delectus animalium articulorum, quae in itinere per Brazilia 1817–1820 JB de Spix et CF Martius, iii + 44 + 224 pp, 40 plates [pages 1–60, 1830; 61–124, 1832; 125–224, 1833]. Impensis Editoris, Monachii [Münich].

Pes AMO, Holzenthal RW, Sganga JV, Santos APM, Barcelos-Silva P, Camargos LM (2018) Order Trichoptera. In: Hamada N, Thorp JH, Rogers DC (Eds) Keys to Neotropical Hexapoda, Thorp and Covich's Freshwater Invertebrates. Academic Press, Elsevier, London, vol. 3, 237–324.

Pictet FJ (1836) Description de quelques nouvelles espèces de Névroptères du Musée de Genève. Mémoires de la Société de Physique et d'Histoire Naturelle de Genève 7: 396–404.

Pinto AP (2019) Odonata. In: Catálogo Taxonômico da Fauna do Brasil. PNUD. Available at: http://fauna.jbrj.gov.br/fauna/faunadobrasil/171

Quinteiro FB, Costa AM, Calor AR (2014) Trichoptera do Semiárido II: Integripalpia. In: Bravo F, Calor A (Orgs). Artrópodes do Semiárido: biodiversidade e conservação. Printmídia, Feira de Santana, 229–244.

Rafael JA, Câmara JT (2019) Megaloptera. In: Catálogo Taxonômico da Fauna do Brasil. PNUD. Available at: http://fauna.jbrj.gov.br/fauna/faunadobrasil/249

R Core Team (2019) R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, available online at: https://www.R-project.org

Rosenberg DM, Resh VH (1993) Freshwater Biomonitoring and Benthic Macroinvertebrates. Chapman & Hall, New York, 488 pp.

Ribeiro MC, Martensen AC, Metzger JP, Tabarelli M, Scarano F, Fortin MJ (2011) The Brazilian Atlantic Forest: a shrinking biodiversity hotspot. In: Zachos FE, Habel JC (Eds) Biodiversity hotspots. Springer, Berlin, 405–434. https://doi.org/10.1007/978-3-642-20992-5_21

Riek EF (1976) The marine caddisfly family Chathamiidae (Trichoptera). Journal of the Australian Entomological Society 15, 405–419. https://doi.org/10.1111/j.1440-6055.1976.tb01724.x

Ríos-Touma B, Holzenthal RW, Huisman J, Thomson R, Rázuri-Gonzales E (2017) Diversity and distribution of the Cad-

disflies (Insecta: Trichoptera) of Ecuador. PeerJ 5: e2851. https://doi.org/10.7717/peerj.2851

Salles FF, Boldrini R (2019) Odonata. In: Catálogo Taxonômico da Fauna do Brasil. PNUD. Available at: http://fauna.jbrj.gov.br/fauna/faunadobrasil/122

Santos APM, Nessimian JL, Takiya DM (2016a) Revised classification and evolution of leucotrichiine microcaddisflies (Trichoptera: Hydroptilidae) based on morphological and molecular data. Systematic Entomology 41: 458–480. https://doi.org/10.1111/syen.12168

Santos APM, Takiya DM, Nessimian JL (2016b) Integrative taxonomy of *Metrichia* Ross (Trichoptera: Hydroptilidae: Ochrotrichiinae) microcaddisflies from Brazil: descriptions of twenty new species. PeerJ 4: 1–54. https://doi.org/10.7717/peerj.2009

Schorr M, Paulson D (2019) World Odonata List. https://www.pugetsound.edu/academics/academic-resources/slater-museum/biodiversity-resources/dragonflies/world-odonata-list2/

Souza WRM, Santos APM (2017) Taxonomic study of the genus *Oxyethira* Eaton 1873 (Trichoptera: Hydroptilidae) from Northeast Brazil: Eleven new species and distributional records. Zootaxa 4236: 484–506. https://doi.org/10.11646/zootaxa.4236.3.4

Sobral-Souza T, Lima-Ribeiro MS, Solferini VN (2015) Biogeography of Neotropical Rainforests: past connections between Amazon and Atlantic Forest detected by ecological niche modeling. Evolutionary Ecology 29: 643–655. https://doi.org/10.1007/s10682-015-9780-9

Steinbauer MJ, Field R, Grytnes J, Trigas P, Ah-Peng C, Atorre F, Birks HJB, Borges PAV, Cardoso P, Chou C, De Sanctis M, Sequeira MM, Duarte MC, Elias RB, Fernández-Palacios JM, Gabriel R, Gereau RE, Gillespie RG, Greimler J, Harter DEV, Huang T, Irl SDH, Jeanmonod D, Jentsch A, Jump AS, Kueffer C, Nogué S, Otto R, Price J, Romeriras MM, Strasberg D, Stuessy T, Svenning JC, Vetaas OR, Beierkuhnlein C (2016) Topography driven isolation, speciation and a global increase of endemism with elevation. Global Ecology and Biogeography 25: 1097-1107. https://doi.org/10.1111/geb.12469

Takiya DM, Santos APM, Pinto AP, Henriques-Oliveira AL, Carvalho AL, Sampaio BHL, Clarkson B, Moreira FFF, Avelino-Capistrano F, Gonçalves IC, Cordeiro IRS, Câmara JT, Barbosa JF, Souza WRM, Rafael JA (2016) Aquatic Insects from the Caatinga: checklists and diversity assessments of Ubajara (Ceará State) and Sete Cidades (Piauí State) National Parks, Northeastern Brazil. Biodiversity Data Journal 4: e8354. https://doi.org/10.3897/BDJ.4.e8354

Thomson RE (2019) A revision of the Neotropical caddisfly genus *Ascotrichia* Flint, 1983 (Trichoptera, Hydroptilidae). PeerJ 7: e7560. https://doi.org/10.7717/peerj.7560

Thomson RE, Holzenthal RW (2015) A revision of the Neotropical caddisfly genus *Leucotrichia* Mosely, 1934 (Hydroptilidae, Leucotrichiinae). Zookeys 499: 1–100. https://doi.org/10.3897/zookeys.499.8360

Ulmer G (1913) Verzeichnis der südamerikanischen Trichopteren, mit Bemerkungen über einzelne Arten. Deutsche Entomologische Zeitschrift 1913: 383–414.

Wasmund AM, Holzenthal RW (2007) A revision of the Neotropical caddisfly genus *Rhyacopsyche*, with the description of 13 new species (Trichoptera: Hydroptilidae). Zootaxa 1634: 1–59.

Wiggins GB (1996) Larvae of the North American Caddisfly Genera (Trichoptera). University of Toronto Press, Toronto, 457 pp.

Wiggins GB (2004) Caddisflies: the underwater architects. University of Toronto Press, Toronto, 292 pp.

Submitted: September 9, 2019
Accepted: December 5, 2019
Available online: September 17, 2020
Editorial responsibility: Ralph Holzenthal

Author Contributions: APMS and LLD conceived the study; APMS, LLD, ALHO, WRMS, LMC, ARC, and AMOP gathered distributional data for species listed, updated the CTFB website, and wrote the paper; APMS performed the statistical analyses.
Competing Interests: The authors have declared that no competing interests exist.
© 2020 Sociedade Brasileira de Zoologia. Published by Pensoft Publishers at https://zoologia.pensoft.net

Supplementary material 1

Supplementary S1. List of Trichoptera species recorded to Brazil until August 2019, indicating endemic species to the country and respective distributional record through biomes, hydrographic regions, and Brazilian states. These data were available at Santos et al. 2019 http://fauna.jbrj.gov.br/fauna/faunadobrasil/278 [accessed on 02 September 2019]

Authors: Allan P.M. Santos, Leandro L. Dumas, Ana L. Henriques-Oliveira, W. Rafael M. Souza, Lucas M. Camargos, Adolfo R. Calor, Ana M.O. Pes.

Data type: species data.

Copyright notice: This dataset is made available under the Open Database License (http://opendatacommons.org/licenses/odbl/1.0/). The Open Database License (ODbL) is a license agreement intended to allow users to freely share, modify, and use this Dataset while maintaining this same freedom for others, provided that the original source and author(s) are credited.

Link: https://doi.org/10.3897/zoologia.37.e46392.suppl1

Supplementary material 2

Supplementary S2. Six biomes in Brazil (as defined by IBGE 2004), with approximate area and caddisfly species recorded (total

number and endemic).
Authors: Allan P.M. Santos, Leandro L. Dumas, Ana L. Henriques-Oliveira, W. Rafael M. Souza, Lucas M. Camargos, Adolfo R. Calor, Ana M.O. Pes.
Data type: species data.
Copyright notice: This dataset is made available under the Open Database License (http://opendatacommons.org/licenses/odbl/1.0/). The Open Database License (ODbL) is a license agreement intended to allow users to freely share, modify, and use this Dataset while maintaining this same freedom for others, provided that the original source and author(s) are credited.
Link: https://doi.org/10.3897/zoologia.37.e46392.suppl2

Supplementary material 3
Supplementary S3. Hydrographic Regions in Brazil (as defined by ANA 2015), with approximate area, number of main basins, and caddisfly species recorded (total number and endemic).
Authors: Allan P.M. Santos, Leandro L. Dumas, Ana L. Henriques-Oliveira, W. Rafael M. Souza, Lucas M. Camargos, Adolfo R. Calor, Ana M.O. Pes.
Data type: species data.
Copyright notice: This dataset is made available under the Open Database License (http://opendatacommons.org/licenses/odbl/1.0/). The Open Database License (ODbL) is a license agreement intended to allow users to freely share, modify, and use this Dataset while maintaining this same freedom for others, provided that the original source and author(s) are credited.
Link: https://doi.org/10.3897/zoologia.37.e46392.suppl3

Supplementary material 4
Supplementary S4. Brazilian states plus the Federal District, with approximate area and caddisfly species recorded (total number and endemic).
Authors: Allan P.M. Santos, Leandro L. Dumas, Ana L. Henriques-Oliveira, W. Rafael M. Souza, Lucas M. Camargos, Adolfo R. Calor, Ana M.O. Pes.
Data type: species data.
Copyright notice: This dataset is made available under the Open Database License (http://opendatacommons.org/licenses/odbl/1.0/). The Open Database License (ODbL) is a license agreement intended to allow users to freely share, modify, and use this Dataset while maintaining this same freedom for others, provided that the original source and author(s) are credited.
Link: https://doi.org/10.3897/zoologia.37.e46392.suppl4

Supplementary material 5
Supplementary S5. Unweighted pair-group average (UPGMA) dendrogram based on Jaccard dissimilarity index of the incidence data of Trichoptera in Brazilian biomes (A) and states (B) respectively. In both analyses, species recorded only in one region were excluded. Values near branches are bootstrap analyses with 10,000 pseudoreplicates. Dendrogram and bootstrap values were calculated in software PAST.
Authors: Allan P.M. Santos, Leandro L. Dumas, Ana L. Henriques-Oliveira, W. Rafael M. Souza, Lucas M. Camargos, Adolfo R. Calor, Ana M.O. Pes.
Data type: species data.
Copyright notice: This dataset is made available under the Open Database License (http://opendatacommons.org/licenses/odbl/1.0/). The Open Database License (ODbL) is a license agreement intended to allow users to freely share, modify, and use this Dataset while maintaining this same freedom for others, provided that the original source and author(s) are credited.
Link: https://doi.org/10.3897/zoologia.37.e46392.suppl5

Supplementary material 6
Supplementary S6. Taxonomic diversity of caddisfly genera recorded in Brazil and main taxonomic efforts published until now, with special attention to species occurring in Brazil. Abbreviations: tax. rev.-taxonomic revision; morp. phy.-morphology based phylogenies; DNA phy.-DNA based phylogenies; COI-citocrome oxidase I gene fragment; descrip.-taxa descriptions; DNA div.-DNA divergencies.
Authors: Allan P.M. Santos, Leandro L. Dumas, Ana L. Henriques-Oliveira, W. Rafael M. Souza, Lucas M. Camargos, Adolfo R. Calor, Ana M.O. Pes.
Data type: species data.
Copyright notice: This dataset is made available under the Open Database License (http://opendatacommons.org/licenses/odbl/1.0/). The Open Database License (ODbL) is a license agreement intended to allow users to freely share, modify, and use this Dataset while maintaining this same freedom for others, provided that the original source and author(s) are credited.
Link: https://doi.org/10.3897/zoologia.37.e46392.suppl6